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An Adaptable Decision Making Model for Sustainable Enterprise Interoperability

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Abstract

The need for modern enterprises to seamlessly interoperate, exchange resources and co-create with other enterprises poses significant challenges on the management of cross-enterprise information flows. This paper aims to introduce new ways for managing: a) information flow (re-)configurations; b) equilibrium state transitions in evolving collaboration networks. Our research effort was focused on the development of an adaptability model that helps entities in a collaboration network manage inter-enterprise information flows, in the presence of dynamic re-configurations of the network. A number of software tools were developed or are currently under development and new avenues are explored for automating the model's adaptability algorithm (e.g. be using Gordijn's e3-value framework). Overall, this research has advanced current thinking in dynamic cross-enterprise information management by providing: a) a model for selecting the desired configuration of a collaboration network, based on a value assessment of corresponding information flows; b) a set of software tools for practically engaging in such a decision-making process.

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Keywords: enterprise interoperability; sustainable interoperability; information management; value co-creation, service management

1. Introduction

Globalization, technological change and an increasing demand for specialization has led to new economic activities, new business models and new value propositions (Johannesson et al., 2010). As enterprises struggle to react to these changes, they realize that they need to increase their collaboration capabilities with business partners,

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by engaging in business networks for exploiting new opportunities and engaging in value innovation (Weigand et al., 2009; Johannesson et al., 2010).

Hence, the need to seamlessly interoperate, exchange resources and co-create with other enterprises poses significant challenges on the management of cross-enterprise information flows (Li et al., 2008; Chen et al., 2008; Charalabidis et al., 2010). Organizations may enter or leave a collaborative network, IT systems and applications may need to be adapted to new market and customer requirements – all leading to evolutions of a collaboration network and constant reconfigurations of information flows (Tapscott et al., 2000; Mele and Polese, 2010).

In such a dynamic environment, the capability to sustain inter-enterprise information flows becomes critical. In other words, promoting sustainable interoperability becomes a challenge of managing different aspects of cross-enterprise information flows.

A number of IT-focused approaches have been proposed for addressing the sustainability challenge, tackling specific aspects of IT systems interoperability. However, a purely technical focus would leave unanswered basic practical questions on business-related issues that, in turn, could hamper the practical acceptance by enterprises of any technical approach to sustainable interoperability. Hence, a credible approach should be more generic, such as the Sustainable Interoperability Framework proposed by (Agostinho and Goncalves, 2009). This framework is based on the premise that collaboration networks resemble Complex Adaptive Systems (CAS), thus leading to a Sustainability Recovery Cycle that controls the evolution of a CAS (i.e. a collaboration network) into new interoperability states amid dynamic changes. In this context, reaching a new state is achieved through a series of steps that require information management reconfiguration.

The objective of this paper is to introduce models and tools that can successfully guide collaboration participants through the aforementioned Sustainability Recovery Cycle and the related information management challenges. To achieve that, we adopt a complementary view to CAS, namely the Service Science concept of Service Systems (Maglio et al., 2009). In Service Science, every enterprise is a service system that interoperates with other service systems (i.e. enterprises) through value propositions (i.e. services). A service system can: (a) match its resources and capabilities with acquired ones for co-creating successful service offerings; (b) sense opportunities and threats for change; and (c) respond to these changes through resource reconfigurations that are usually knowledge-related (Kutsikos and Mentzas, 2012; Smith and Ng, 2012).

The research started with a critical analysis and focus on the key characteristics of enterprise interoperability (EI) that need to be sustained amid dynamic changes in a collaboration network. (Li et al., 2008), identify four such characteristics that depend on cross-enterprise information management: knowledge-driven innovation, value co-creation, demand-driven customization and service portfolio management. If we assume that these characteristics collectively define an 'EI state', then the goal of the sustainability recovery cycle is to define an evolution path to a new 'EI state', potentially selecting among many different ones.

Relevant research questions then emerge: a) what is the specific structure of an 'EI state' ? b) how is 'EI state' transition defined ? c) what information management models and tools need to be developed in order to realize 'EI state' transition within a sustainability recovery cycle?

In order to address these questions, we first defined the specific context of this research, based on our previous experience in collaboration networks through the EU FP7 'SYNERGY' project (Popplewell et al., 2008) (Verginadis et al., 2011) (Kutsikos and Mentzas, 2011), as well as on relevant literature review. We thus defined a collaboration network as a collection of service systems. Each node in the network (i.e. each service system) is a dynamic configuration of resources and capabilities (knowledge, skills). Interoperability is exhibited through services that enable nodes to integrate resources and capabilities acquired from other nodes. In this context, service management becomes a key mechanism for managing information flows which, in turn, lead to value co-creation.

Based on these premises, we developed an 'EI state' Adaptability Model that helps collaboration network participants to manage inter-enterprise information flows and select a new equilibrium state for the network. The model is comprised of nine generic 'EI state' classes, corresponding to nine different value co-creation strategies that are defined by a set of value co-creation attributes.

The structure of this paper follows our research approach. Section 2 describes relevant concepts used in our research, with emphasis on the Sustainable Interoperability Framework (Agostinho and Goncalves, 2009). Section 3 builds on this framework and presents in detail the development of our Adaptability Model, followed by a description of EI transitions in Section 4. Finally, conclusions and comments on further research comprise Section 5.

2. Literature Review

In the past decade, Enterprise Interoperability has received considerable attention in the research community (Chen et al., 2008). This is because enterprises must increasingly collaborate and establish partnerships to reach global markets (Charalabidis et al, 2010). As enterprises cannot survive and prosper solely through their own individual efforts, each one's success depends on the activities and performance of others with whom they do business, and hence on the nature and quality of the direct and indirect relations. In this context, Enterprise Interoperability is defined as the capability of an organization to interact and exchange information and other resources both internally and with external partners, in order to achieve a certain business goal (Li et al., 2008).

In order to succeed in this collaborative environment, enterprises need to be interoperable, thus being able to share technical-level and business-level information seamlessly within and across organizations, and must be adaptable to different network environments at all life cycle phases (Goncalves et al., 2007). Nevertheless, due to different models, semantics and information structures, organizations are experiencing difficulties in exchanging vital information, even when they operate in related business environments. Ultimately, the advent of market dynamics results in the loss of stability of the enterprise interoperable environment through failure of harmonization (Agostinho and Goncalves, 2009).

This turns the spotlight to the emerging concept of sustainable interoperability. Sustainable interoperability, being a new dimension to interoperability research, refers to the ability to smoothly accommodate disturbances in a network of organizations, without compromising the overall network interoperability state (Agostinho et al., 2011; Goncalves et al., 2012).

Current research in sustainable interoperability is inspired from Complex Adaptive Systems (CAS) and their capability of autonomously adapting to environmental changes by exploiting properties like: autonomy, self-organization, ability to learn and co-evolution. A seminal CAS-based framework is the Sustainable Interoperability Framework, defined by (Agostinho and Goncalves, 2009; Goncalves et al., 2012).

Such a framework must exhibit number of capabilities that are needed for managing different information flows in a collaboration network: a) discovery capabilities, for monitoring events that may affect a collaboration network; b) learning capabilities, for assessing the impact of discovered events on the smooth operation of the collaboration network; c) adaptability and transient analysis capabilities, for designing and testing responses and solutions to the strategic and operating changes that may need to be implemented so that the collaboration network reaches a new equilibrium state; d) notification capabilities, for communicating to all partners the potential transformation that the collaboration network must undertake in order to sustain its interoperability quotient.

2.1. Service systems and complex adaptive systems

The multidisciplinary nature of enterprise interoperability has led to the emergence of service science as a new academic discipline (Spohrer and Maglio, 2008). Researchers in this field aim to apply the characteristics of service orientation from the information systems discipline to the business domain and vice-versa, in order to explain how dynamic service entities, termed service systems (i.e. enterprises), interact and evolve to co-create value (Fischbach et al, 2011). (Maglio et al, 2009) further elaborate on the notion of service systems, by abstracting them as dynamic configurations of people, technology, resources and value propositions connected to other service systems through shared information flows. Hence, all service systems are resource integrators as they mobilize and transform specialized competences (knowledge and skills), as well as other internal and market-acquired resources, into offerings that have value for themselves and others (Smith and Ng, 2012).

Service systems are a special case of complex adaptive systems. They are complex in that they are diverse and made up of multiple interconnected elements, and adaptive in that they have the capacity to change and learn from their operation and experience (Spohrer and Kwan, 2009). Complexity science, as a foundation discipline for service science, aims to provide insights for understanding how improvements or failures in one service system can be spread (scale out and scale up) to other service systems, both within and between different types of service systems (Spohrer and Kwan, 2009).

3. The Proposed Adaptability Model

Our research is based on the Sustainable Interoperability Framework, introduced by (Agostinho and Goncalves, 2009), briefly described in the previous section. Its key element, the Sustainability Recovery Cycle (SRC), acts as an equilibrium-inducing mechanism. A new interoperability state is thus reached when a full cycle is completed.

In this context, the first challenge is to define what an interoperability state is. Our approach in addressing this challenge is based on isolating the key characteristics of enterprise interoperability and cross-enterprise information management that need to be sustained amid dynamic changes in a collaboration network. (Li et al., 2008) identify four such characteristics: knowledge-driven innovation, value co-creation, demand-driven customization and service portfolio management. In turn, we define as 'EI state' an equilibrium state for a collaboration network that is: a) reached at the end of a SRC iteration; b) described as a 2-tuple expression:

EI state: <CTasks, CMgmt>

CTasks is comprised of the set of collaboration tasks that are executed within a collaboration network, at a given equilibrium point. These tasks pertain only to interoperability activities, excluding all internal activities of network participants. CTasks are knowledge objects, depicted as Collaboration Patterns (Papageorgiou et al., 2009). Collaboration Patterns (CPats) describe the forms of collaboration in a collaboration network and the proven solutions to a collaboration problem. They essentially provide a mechanism for expressing and executing process-centric collaboration models, as well as ad-hoc information exchanges. This is achieved by supporting both workflow-based solutions, as well as lists of freely configurable actions. Workflows are useful for process-centric collaborative work and action lists help users collaborate by informing them about the tasks they have to perform and the resources they may need in each step, while allowing users to modify them in order to adequately support the specificities of the on-going collaboration.

CMgmt is comprised of a set of attributes that instantiate specific information management activities within a collaboration network, at a given equilibrium point. CMgmt attributes are driven by value co-creation and encompass both business and IT issues encountered in collaboration networks. Currently, five such attributes are defined: Value Allocation, Partners Management, Contract Management, Coordination Cost, and Performance Management.

Value Allocation refers to revenue sharing among collaboration network participants. However, the existence of other value distribution mechanisms is possible (e.g. rewards for exceeding targets).

Partners Management refers to alignment of needs and expectations of collaboration network participants. Formal policies to educate partners for value co-creation are embedded in this attribute. Access rights to specialized resources, competences and co-created knowledge assets (CPats) are also part of this attribute, as well as semi-formal policies for supporting a trust-based environment.

Contract Management refers to the establishment of formal contractual agreements and service-level agreements which delineate partners' rights and obligations regarding co-created offerings. Sanctions, in case the contract terms are not obeyed, are also defined in this attribute. Finally, governance issues are defined through roles and responsibilities of the collaboration network participants.

Coordination Cost refers to the IT and managerial costs (time, IT investments, IT systems) for coordinating a large set of potential partners. Risk management practices for alleviating the challenges of depending on external resources for a given offering, along with emergency plans, are also defined.

Performance Management refers to the analytical side of the collaboration network's operations, where qualitative and quantitative data are consolidated, evaluated and disseminated to participants for improving their performance. Customer usage is also analyzed, thus enabling a holistic conceptualization of the performance rate and quality levels of the collaboration network.

4. EI State Transitions

An EI state transition is triggered when a harmonization failure (assessed at the Learning phase of a SRC iteration) necessitates a change in any or both of the elements (CTasks, CMgmt) of a collaboration network's current EI state.

In order to develop a practical understanding of EI transitions, we limit the scope of our research to the Adaptability and Transient Analysis phases of a SRC. In addition, the following assumptions are made that define the context of this research. Firstly, based on previous experience in collaboration networks through the EU FP7 'SYNERGY' project, we adopt a Service Science viewpoint: enterprises are service systems that exchange information flows with other service systems (i.e. enterprises) via services, for acquiring resources and capabilities. The goal is to integrate the latter with their own for developing new offerings, thus leading to value co-creation in a collaboration network of service systems. In this context, an EI state transition must be directly linked to reconfiguration of resources and capabilities, in order to sustain the value co-creation capacity of the collaboration network.

Second, we focus specifically on the CMgmt element of an EI state because: a) it is the unexplored part in our overall research work; b) it is the value assessment mechanism for an EI state transition, thus ensuring the practical viability of the next EI state.

Based on the above, we developed an EI State Adaptability Model (see Figure 1). It is comprised of nine generic EI state classes that are defined based on the CMgmt attributes. These classes reflect different sets of generic requirements for proper management of a collaboration network.

Collective knowledge

Resource-based view	Commodities/ Base-generic	Commodities + market options (value enhancements)	Knowledge creation/ new service development/value added EI
Dependent Resources	SC7	SC8	SC9
Combined Resources	SC4	SC5	SC6
Core Resources	SC1	SC2	SC3

Fig. 1. Our EI state adaptability model

An EI state transition is then defined as a process with the following steps: a) collect information relevant to the CMgmt attributes during the Discovery and Learning phases of SRC; b) change, if needed, CTasks and define their impact on CMgmt attributes; c) select one or more EI state classes that best match the requirements stemming from the previous steps; d) assess value of requirements that stem from the selected EI state classes; e) on failure, return to step b). In other words, the model helps a collaboration network to create a set of next EI states and then select one, based on how desired values of CMgmt attributes best match one of the generic EI states of the model. Although this process may be automated for certain values, a real operating environment may necessitate human intervention (e.g. business strategy reformation, or new IT outsourcing deals).

The vertical axis of our model captures the 'richness' of the value co-creation process input elements. This is achieved by capturing the extent to which resources (business, IT) and their embedded capabilities manifest functional dependency. Core resources refer to basic building blocks that are required for co-creating "cost-driven" offerings. Such resources are usually owned by and exist within the portfolio of any service system (i.e. enterprise).

Combined resources refer to the combination of two or more core resources that may be owned by different service systems and exhibit no functional dependency among each other. Dependent resources are similar to Combined resources, but with functional dependency among its constituent core resources. Such resources are higher-order resources and cannot simply be recreated by rendering the individual parts independently.

The horizontal axis captures the complexity of the value co-creation activities and the management of the related information flows. This axis assumes that not all value co-creation activities require significant involvement and control of capabilities, resources and management processes. Such activities may be deemed “low” in value co-creation and consequently affect the quality and performance of the service offering. A “low” value co-creation offering is represented as a commodity knowledge-based offering. On the other hand, activities that are deemed “high” in value co-creation may enable strategic alliances that result in new knowledge capabilities and increase the overall performance of the collaboration network.

An EI state that falls into quadrant SC1 reflects a collaboration network where value co-creation opportunities are undertaken on an ad-hoc basis with a limited number of participants and information exchanges. The generic values for the CMgmt attributes for SC1 EI states are:

SC1.Value Allocation: there is limited need for establishing a revenue sharing structure, as partners are involved in co-creation activities on a limited basis. Given the commodity nature of the service offering, its price structure is fixed.

SC1.Partners Management: limited use of specialized policies, rules and processes for aligning co-creators’ expectations, as external resources may be provided as fixed sets and on an ad-hoc basis. As a result, loose ties of commitment and trust can be expected when external partners are engaged.

SC1.Contract Management: limited use of formal policies and governance structures are required. Existing contract templates can be re-used from previous deals, which result in a minimized cost for contract initiation or re-negotiation. There is limited need for a sanction policy, as only existing core resources are used.

SC1.Coordination Cost: limited coordination costs can be expected, given the absence of significant level of resource exchanges. Thus, there is no need for specialized risk management activities.

SC1.Performance Management: given limited value co-creation activities, limited amount of relevant information is exchanged and aggregated, thus lowering the cost and time effort for analyzing the resulting information. The aggregated data may be restricted solely to the usage rates from the end-user perspective.

An EI state that falls into quadrant SC9 reflects a collaboration network where value co-creation activities are extensive and may also result in significant knowledge creation. The generic values for the CMgmt attributes for SC9 states are:

SC9.Value Allocation: a revenue sharing structure will reward co-creators based on their participation, the quality of the resources they provide and their adherence to formal policies. Since co-created knowledge assets may act as core resources in future value co-creation activities, issues like time value and derivative value of these assets must be formally defined in the revenue sharing structure.

SC9.Partners Management: specialized policies are required for ensuring tight commitment and the iterative alignment of co-creators expectations and needs based on the resources they provide. As a result, shared access to specialized resources, competences, know-how, proprietary IT infrastructure and co-created knowledge assets can be expected. The collaborative network coordinating enterprise may set up a specialized business unit for managing co-creators, especially if these is a need for culture and norms alignment.

SC9.Contract Management: formal policies and governance structures are required for properly defining contract information - the roles, responsibilities, rights and obligations of the co-creators, thus eliminating opportunistic behavior which may result from providing access to specialized resources and knowledge assets. Given the complexity of interactions, the usage of ready-made contract is impossible, potentially leading to outsourcing of contract activities. A well-structured sanction system exists which may include contract renegotiation CTasks.

SC9.Coordination Cost: high coordination and information management costs can be expected, given the high degree of interoperability. Subsequently, this may result in the establishment of a risk management business unit by the collaboration network coordinating enterprise, for alleviating the challenges of depending on external resources, as well as to define emergency plans.

SC9.Performance Management: qualitative and quantitative data regarding each used resource are aggregated, evaluated and disseminated to co-creators in order to assess their performance and improve their quality levels.

Usage and acceptance rates of the co-created knowledge assets from the consumers perspective are also analyzed, thus enabling a holistic conceptualization of the performance rate and the quality level of value network. It is expected that specialized business analytics and CRM applications may be used by the collaboration network coordinating enterprise, or may even outsource these activities to specialized partners.

5. Conclusions and further research

The objective of this paper was to introduce a new model for managing information flow reconfigurations and equilibrium state transitions in evolving collaboration networks. The undertaken research was based on the Sustainable Interoperability Framework (Agostinho and Goncalves, 2009) and its proposed Sustainability Recovery Cycle.

In this context, the paper explored three relevant research questions: a) what is the structure of an equilibrium state ('Enterprise Interoperability State')? b) how is 'EI state' transition defined ? c) what information management models and tools need to be developed in order to realize 'EI state' transition within a sustainability recovery cycle ?

By adopting a Service Science viewpoint, we focused our approach on collaboration networks of service systems – a good proxy for the complex adaptive systems focus of the Sustainable Interoperability Framework. The added advantage is that service systems are inherently collaborative entities, as they interoperate with other service systems through exchange and integration of information and other resources for value co-creation. This leads to our viewpoint on sustainable interoperability: it is about sustaining the value co-creation capacity of a collaboration network.

Based on these premises, we presented an EI State Adaptability Model that helps collaboration network participants to assess and select a new equilibrium state for the network, with a specific value co-creation profile. A key characteristic of this model is that an EI state is specifically defined as a set of collaboration tasks across the network, along with a set of related network management activities. Hence, an EI state transition is triggered when either or both of these sets are affected by an inflicted change.

Managing state transition is the ongoing focus of our research. A number of software tools were developed or are currently under development. We are also exploring other scholars' research outcomes, such as the e3-value framework, that can help automate certain aspects of the decision-making process for state transitions. A key remaining challenge is the practical deployment of this model and the related development of actual case studies.

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